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RESEARCH OF UV SHIELDING PROPERTIES OF POLYESTER/VISCOSE WOVEN FABRIC

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ABSTRACT

The aim of present work was to develop the fabric which provides shielding from ultraviolet rays present in the sunlight. Carded Polyester/Viscose Ring yarns with Blend ratios 75/25, 60/40, and 55/45 and Polyester/Viscose/Lycra Ring yarns with blend ratio 70/25/5 having linear density of 20 Tex were produced. The fabric samples were woven with constant warp density of 125 ends per inch and for each blend three weft densities (65, 80, 95 picks per inch) were selected. Combining all, twelve different samples of fabric were prepared. These fabrics were first treated with pre-treatment process and then dyeing of all samples were carried out by using disperse dye and reactive dye for Polyester and Viscose respectively. The UPF of the fabric was determined by the in vitro method using an Ultraviolet Transmittance Analyser UV-2000F. Results show excellent UPF along with good air permeability and provide best protection in UVB and UVA region for all the samples.

KEYWORDS: Polyester, Viscose, Lycra, Woven Fabric, UV Shielding

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Original Article

INTRODUCTION

The past two decades have witnessed an alarming increase in the incidence of skin cancer worldwide which is primarily attributed to stratospheric ozone depletion caused by enormous use of CFCs as coolants [1]. The stratospheric ozone layer serves as the earth's main natural protection against harmful ultraviolet radiation from the sun. Because ozone is a very effective UV-absorber each one percent decrease in ozone concentration is predicted to increase the rate of skin cancer by two percent to five percent [2, 3].

Although UV rays constitute a very low (2% -5%) fraction in the solar spectrum, but it has profound influence on all the living organisms. These radiations can cause range of effects from simple tanning to highly malignant skin cancer. The other effects include premature ageing of skin, wrinkling, weaken body's immune system, allergies, and can cause eye disorder etc. So everyone should remain protected from blazing sunlight. The common protection are reducing time spent in blazing sunlight, use of sun screen lotions, seeking shade and using clothing's that can provide maximum protection. Textiles can provide simple and effective protection against damaging UV radiation because they are able to reflect, absorb and scatter solar wavelengths, but in most of the cases it does not provide full sun screening properties. When UV radiation strikes a textile surface, some of the radiation is reflected at the boundaries of the textile surface. Another radiation element is absorbed when it penetrates the sample: more accurately, converted to a different energy form. The remaining part of the radiation passes through the fabric and reaches the skin: this part is referred to as transmission [4].

Many research studies were conducted to establish the parameters that affect the UV permeability of the textile garment. Some studies concluded that the compactness and weight of the fabric are most relevant parameters; while others claim that dark colour shades offer more protection. The construction or weave of the fabric is the most important factor affecting UVR transmission [5]. The arrangement of yarns and fibres determined by fabric construction can influence the compactness of the structure, together with the open space within the fabric [6, 7].

Aim of the present study was to engineer a blended yarn of correct linear density from different blend ratios which contain synthetic fibre (Polyester) for providing sun shielding property and Viscose fibre to obtain its benefit of cotton like properties in giving comfort to the wearer and optimization of fabric parameters like type of weave, warp density and weft densities to obtain various cover factor to weave fabrics of excellent sunshield properties.

MATERIALS AND METHODS

For this work Carded Polyester/Viscose Ring yarns with Blend ratios 75/25, 60/40, and 55/45 and Polyester/Viscose/Lycra Ring yarns with blend ratio 70/25/5 having linear density of 20 Tex were produced. The fabric samples were woven on Dornier make Rigid Rapier Loom with constant warp and weft linear density of 20Tex and warp density of 125 ends per inch for all samples. For each blend three weft densities (65, 80, 95 picks per inch) were selected. Combining all, twelve different fabric samples were prepared. Table 1 shows the experimental design of the woven samples. These fabrics were first treated with pre-treatment process and then dyeing of all samples were carried out by using disperse dye and reactive dye for Polyester and Viscose respectively. Prior to testing all fabrics samples were conditioned and tested in a standard atmosphere. The characterisation of all samples was carried out on ready for Dyeing (RFD) and dyed samples.

TEST METHODS

Performance tests applied to the fabrics in the study and standard methods are shown in table 2.

Ultraviolet Protection Factor UPF

The UPF of the fabric was determined by the in vitro method using an Ultraviolet Transmittance Analyser UV-2000F according to standard BSEN 13758-1:2002. The UV-2000F Ultraviolet Transmittance Analyzer is the most recent and highly application specific ultraviolet spectroscopy. The instrument operates by measuring the diffuse transmittance of a fabric sample as a function of wavelength in the ultraviolet spectrum (250 nm to 450 nm) and does the automatic calculations of spectral transmittance, UPF, critical wavelength and UVA: UVB ratios. Each fabric sample was tested for five different locations to cover entire length and width of fabric, the measuring area was 0.67 cm^2 and wavelength accuracy to +1 nm [8].

Calculation of UPF

The UPF of a textile material is determined from the total spectral transmittance. The total spectral transmittance is measured by irradiating the sample with monochromatic or polychromatic UV radiation and collecting the total (diffuse and direct) transmitted radiation. In the case of polychromatic incident radiation, the transmitted radiation is collected monochromatically. The apparatus shall either irradiate the sample with a parallel beam and hemispheric ally or collect a parallel beam of transmitted radiation.

Calculation of the arithmetic mean of the UVA transmittance (UVAi) for each sample I am as follows:

$$UVA_i = 1/m \sum_{\lambda=315}^{\lambda=400} Ti(\lambda)$$

Calculation of the arithmetic mean of the **UVB** transmittance (UVBi) for each sample I am as follows:

$$UVB_i = 1/k \sum_{\lambda=290}^{\lambda=315} Ti(\lambda)$$

Where:

Ti (λ) is the spectral transmittance of specimen I at wavelength λ, m and k are the measurement points between 315nm and 400 nm and between 290nm and 315 nm respectively.

Calculation of the Ultraviolet Protection Factor for each specimen I am as follows:

$$UPF = \frac{\sum_{\lambda=290}^{\lambda=400} E(\lambda)S(\lambda)\Delta\lambda}{\sum_{\lambda=290}^{\lambda=400} E(\lambda)S(\lambda)T(\lambda)\Delta\lambda}$$

Where E (λ) = CIE erythemal spectral effectiveness, S(λ) = solar spectral irradiance in Wm-2 nm-1, T(λ) = spectral transmittance of fabric, Δλ = the bandwidth in nm, and λ = the wavelength in nm [9, 10, 11, 12, 13, 14, 15].

RESULTS AND DISCUSSIONS

Table 3 shows fabric properties and experimental air permeability values of RFD Sateen Samples. As weft density increases, weight increases which reduces the total fabric porosity and results in the reduction of the direct transmission of UV rays through the pores of fabric, in addition to that blended yarn is used which contains the component of Polyester and Viscose in different proportion. Polyester due to its large conjugated aromatic polymer system is very effective in blocking UVB radiation. Polyester is less effective against the UVA radiation because its UVR transmission increases significantly at 313 nm which is close to the boundary between the UVB and UVA spectral regions. However, researchers succeeded in rectifying this drawback by increasing the weft density to optimum value and by addition of small percentage of Lycra (5 percent) which is quite evident from the results obtained. Table 4 shows UPF values of Sateen Samples. Figure 1 and 2 shows the percentage Transmittance value of RFD and Dyed samples respectively.

Effect of Construction and Grams on UV Permeability of Fabric

For blend ratio of 75/25, 60/40 and 45/55 (Polyester/Viscose) and 70/25/5 (Polyester/Viscose/Lycra) of RFD samples as weft density increases from 65, 80, 95 picks per inch respectively the effect on thickness is minimal but weight increases which shows good correlation with air permeability values following a decreasing trend and also offers better protection from UV rays emitted by sun, as UPF value is also showing increasing trend which relates well with established fact.

It has been observed that percentage transmittance for the wavelength of 290 to 400 nm, as wavelength increases in a span of 5 nm percentage transmittance increases which is attributed to long wavelength. All the samples offer best protection from UVA and UVB. Fabric woven with Lycra specifically offers best protection from UVB.

By addition of 5 percent Lycra to 75/25 blend it has been observed that UPF increases drastically for 65, 80 and 95 picks per inch weft density. The UPF value increased to 465.23, 503.92 and 53.5.86 from 128.14, 218.14 and 316.99 respectively as addition of Lycra reduces the pore area.

Effect of Blend Ratio on UV Permeability of Fabric

For 65 ppi as blend ratio changes from 75/25, 60/40, 45/55 and 70/25/5 as proportion of Polyester decreases UPF value increases which is rather surprising but it is advantageous from the comfort point of view as viscose proportion increases.

For 80 ppi, effect of blend ratio has been found minimal on UPF and all the samples show equally excellent UV shielding properties. For 95 ppi 75/25 blend shows highest UPF value with good air permeability.

All Dyed fabrics shows significant increase in UPF value (around 2000) compared to RFD samples which itself falls into the range of excellent sun shielding fabrics. All Dyed fabrics shows very good protection from UVA and UVB rays as percent transmittance range from 0.05 to 0.1 percent. As the absorption band for all dye, extends into the UVR radiation band (290 to 400 nm) and hence dye act as effective UVR absorber. The extinction coefficients of the dyes in the UVR spectral band determine their ability to increase fabric protectiveness against UV radiation [16].

CONCLUSIONS

For all blend ratios chosen for study, it has been observed that with increase in weft density weight increases, air permeability decreases and UPF value increases. It has been observed that for every blend ratio chosen the percentage transmittance decreases for every wavelength with increase in weft density. It has been observed that all the samples shows increasing trend in percentage transmittance from 290 to 400 nm which is attributed to longer wavelength and thus shows best protection in UVB region than UVA.

All the samples exhibit excellent UPF (greater than 100) with good to very good air permeability. Addition of Lycra by just 5 percent increases the UPF value significantly for all the samples. Yarn produced with all four blend ratios exhibits better performance in terms of sun shielding properties. Blend ratio 75/25 and 45/55 without Lycra produces the best fabric. The combination of fabric structural properties (weave, fibre type, linear density and fabric sett) has great direct and indirect effect on thickness, weight, porosity of fabric and so in the transmission of UV radiation through the fabric. All the dyed fabric exhibits extremely high value of UPF (2000). Researchers succeeded in engineering yarn as well as fabric from medium to heavy weight which is capable of protecting the wearer even with highest UV index of (10-12).

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REFERENCES

1. *Geethadevi R & Maheshwari V. (2013). Application of herbal oil on selected regenerated cellulosic fabric for evaluating the UV protection property. J Textile Sci Eng.Vol 3, Issue 4.*
2. *A.K.Sarkar. (2005). Textiles for UV protection, Richard A. Scott (edi) Textiles for protection, Cambridge: Wood head Publishing Ltd., 355-377.*

3. *Polona Dobnik Dubrovski & Darko Golob. (2014). Effects of woven fabric construction and color on ultraviolet protection. Textile Reseach J Vol. 79(4):351-359, accessed on October 10, 2014, trj.sage.pub.com.*
4. *K. Hoffmann et al. (2000). J Am Acad Dermato. 43, 1009-1016.*
5. *Peter H. Gies et al. (1998). Protection against solar ultraviolet radiation. Mutation Research. 422, 15-22.*
6. *Wai-yin Wong, Jimmy Lwok-Cheong Lam, Chi-wai Kan et al. (2013). Influence of knitted fabric construction on the ultraviolet protection factor of griege and bleached cotton fabrics. Textile Res J. 83 (7); 683-699.*
7. *Krste Dimitrovski, Franci Sluga & Raša Urbas. (20100. Evaluation of the structure of monofilament PET woven fabrics and their UV protection properties. Textile Res J. Vol.80 (11):1027-1037.*
8. *UV-2000F Ultraviolet Transmittance Analyzer User Guide, March 2011-Revision 1.*
9. *Peter Gies. (2007). Photo protection by clothing. Photomed. 23:264-274.*
10. *Anita Tarbuk, Ana Marija Grancaric, Mirna Šitum & Mladen Martinis. (2010). UV clothing and skin cancer. Coll. Antropol. 34 Suppl. 2: 179-183.*
11. *Daniele Grifoni, Laura Bacci, Gaetano Zipoli, Giulia Carreras, Silvia Baronti & Francesco Sabatini. (2009). Laboratory and outdoor assessment of UV protection offered by Flax & Hemp fabrics dyed with natural dyes. Photochemistry and Photobiology. 85:313-320.*
12. *Gies H.P, Roy CR., Elliot G, and Z. Wong. (1994.) Ultraviolet radiation factors for clothing. Health Physics. 67, 131.*
13. *Polona Dobnik Dubrovski & Darko Golob. Effects of woven fabric construction and colour on ultraviolet protection. Textile Reseach J Vol 79(4):351-359, accessed on October 10, 2014, trj.sage.pub.com.*
14. *S Kathirvelu et al. (2000). UV protection finishing of textiles using ZnO particles. Indian Journal of Fibre & Textile Research. Vol.34, 267-273.*
15. *Polly Chiu & Jimmy K.C. Lam. (2010). Denser knitwear fabrics block ultraviolet rays more effectively. ATA Journal for Asia on Textile & Apparel. April Issue.*
16. *Pailthrope. M. (1998). Apparel textiles and sun protection: a marketing opportunity or a quality control nightmare? Mutation Research. 422, 175-183.*

APPENDICES

Table 1: Experimental Design of Woven Samples

Sample No.	Fibre Composition	Blend Ratio	Weave Structure	Weft Density (PPI)
1.	Polyester/Viscose	75/25	Sateen	65
2.	Polyester/Viscose	60/40	Sateen	65
3.	Polyester/Viscose	45/55	Sateen	65
4.	Polyester/Viscose/Lycra	70/25/5	Sateen	65
5.	Polyester/Viscose	75/25	Sateen	80
6.	Polyester/Viscose	60/40	Sateen	80
7.	Polyester/Viscose	45/55	Sateen	80
8.	Polyester/Viscose/Lycra	70/25/5	Sateen	80
9.	Polyester/Viscose	75/25	Sateen	95
10.	Polyester/Viscose	60/40	Sateen	95
11.	Polyester/Viscose	45/55	Sateen	95
12.	Polyester/Viscose/Lycra	70/25/5	Sateen	95

Table 2: Performance Tests Applied in the Study and Standards

UV permeability and protection factor test	BSEN 13758-1:2002	UV-2000F (Lab sphere)
Fabric Thickness Test	ASTM:D 1777:197, IS:77021975	Baker Make J02 Thickness Tester
Fabric Grams Test	ASTM:D 3776-1996, IS:1964-2001	Mettler make measuring balance , model PB 602-5
Air permeability Test	ASTM: D737-1996	SDL Atlas make Air Permeability tester Model : MO21A

Table 3: Fabric Properties and Experimental Air Permeability Values for RFD Sateen Samples

Fabric Code	Thickness, (mm)	Weight, g/m^2	Air Permeability, ($l/m^2/s$)
1.	0.478	171.95	649
2.	0.501	178.99	493
3.	0.485	173.97	638.4
4.	0.636	252.43	91.32
5.	0.475	199.09	143.8
6.	0.498	194.28	264
7.	0.505	193.85	311.8
8.	0.659	288.26	41.14
9.	0.483	205.18	129.2
10.	0.508	216.04	128.8
11.	0.508	218.13	145.8
12.	0.655	299.52	30.06

Table 4: UPF of Sateen Samples

Fabric Code	Mean UPF		Mean UVA		Mean UVB	
	RFD	Dyed	RFD	Dyed	RFD	Dyed
1.	128.14	1890.98	7.88	0.09	0.06	0.05
2.	153.96	1886.46	3.99	0.10	0.05	0.05
3.	156.14	1928.59	6.10	0.08	0.06	0.05
4.	465.23	2000	2.81	0.05	0.05	0.05
5.	218.14	2000	5.59	0.05	0.05	0.05
6.	214.53	2000	5.32	0.05	0.05	0.05
7.	216.12	2000	4.95	0.05	0.05	0.05
8.	503.92	2000	2.65	0.05	0.05	0.05
9.	316.99	2000	3.87	0.05	0.05	0.05
10.	248.50	2000	5.01	0.05	0.05	0.05
11.	271.06	2000	4.41	0.05	0.05	0.05
12.	535.86	2000	2.45	0.05	0.05	0.05

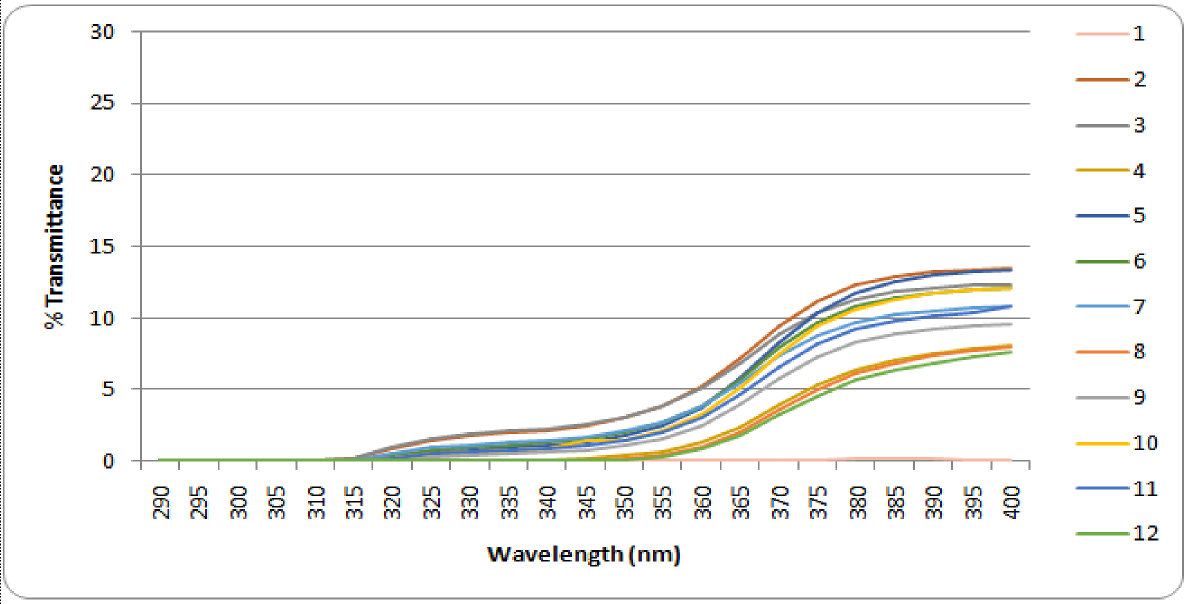

Figure 1: Percentage Transmittance Values of Woven Fabrics of RFD Samples

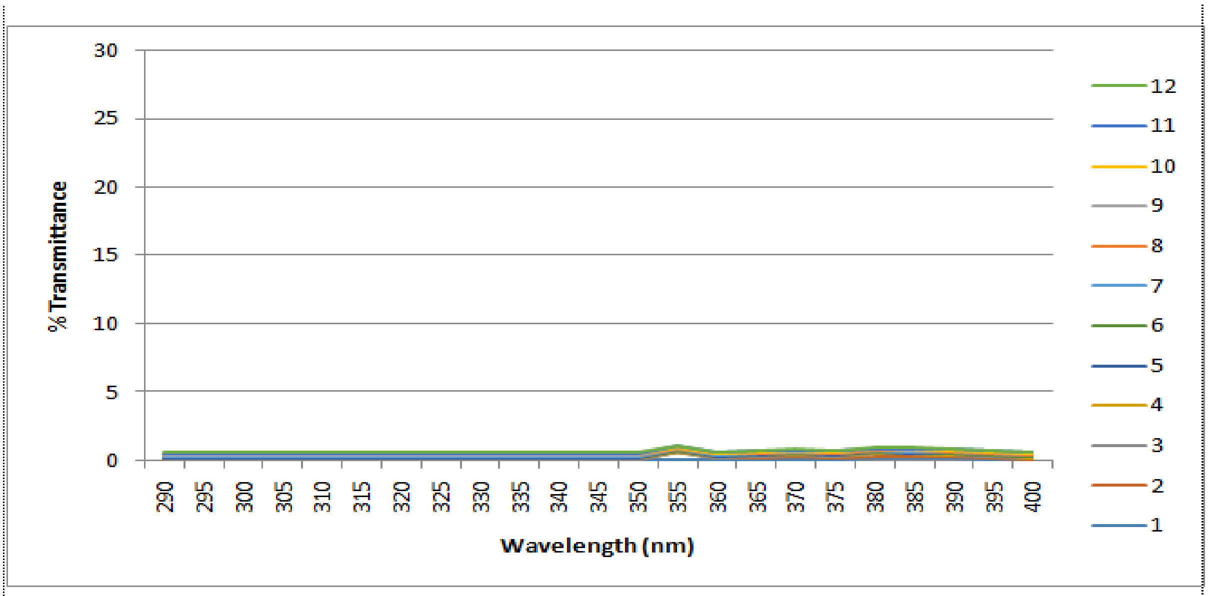

Figure 2: Percentage Transmittance Values of Woven Fabrics of Dyed Samples